FOUR LEG NEWS

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HI THERE FOURLEG FOLKS …

I am so very excited to bring you this newsletter. It was a monumental task to put together! Searching for the articles, sorting through them, reading, noting, and then compiling the grouped info…oh and editing too! Two of us (my virtual assistant Joanne & I) put so many hours into this that I refuse to toss all of the info into just one newsletter. So the Jan-Feb newsletter will be a two-parter (part A & B).

I am loving this modality and use it in conjunction with laser and acupuncture most frequently. Now, just like laser, there are lots of differences between the types of machines out there… and this will help you to sort through what is being talked about when you chat-up the sales people or when you want to search research on your own.

And for those of you already using shock wave, this will provide you with research on where it is working and at what dosages.

Like I already said, this was a HUGE task… so I hope you all enjoy the information!

Cheers!

Laurie

What is Shockwave?

Extracorporeal shockwave therapy (ESWT) began with an incidental observation of osteoblastic response pattern during animal studies in the 1980s that generated an interest in its use therapeutically. The basic science behind ESWT is analogous to lithotripsy, the technology that uses acoustic shockwaves to break up kidney stones without surgery. Lithotripsy has been around for approximately 35 years now, and in the process of treating thousands and thousands of patients, it was found that many people undergoing the procedure had other unrelated aches and pains disappear. It was at this point that scientists began to consider that shockwaves might have an effect to heal other sorts of tissues.

Shockwaves are pressure waves (or sound / acoustic waves). They are oscillating mechanical waves that can travel through gas, liquids and solids. They are non-linear pressure waves, characterized by a short rise time (i.e. 10us). They have an extremely high energy peak, like ones which occur in the atmosphere after an explosive event such as a lightning strike or a sonic boom. A shockwave differs from ultrasound by its extremely large pressure amplitude. Additionally, ultrasound usually consists of a periodic / biphasic oscillation (with a peak pressure of 0.5 bar), whereas a shockwave is a single pulse / uniphasic wave (with a peak pressure as high as 500 bar).

Both the positive and negative phase of the shockwave have an effect on interfaces between tissues with different density (acoustic impedance). The positive phase creates a direct mechanical force that results in the maximal beneficial pulse energy concentrated at the target point where treatment is provided. The absorbed shock waves produce a tensile force, and this tensile force accounts for the direct effect. The negative phase creates a secondary effect via cavitation at the tissue interfaces (air bubbles are formed, which subsequently implode with high speed, which generates a second wave of shockwaves or "microjets of fluid"). The bubbles expand, contract, collide, and form other bubbles in the treated tissues. The resulting energy also stimulates a biologic response, the so-called indirect effect. However cavitation also has the potential to cause negative effects or damage to tissues. (But I was unable to find further information on this phenomenon specifically – LEH)

Two Types of SHOCKWAVE Therapy

There are two types of shockwave therapy. Focused shockwave therapy (FSWT) and radial shockwave therapy (RSWT).

FSWT

This type of shockwave is 'focused' because a pressure field is generated that converges in the adjustable focus at a selected depth in the body tissues, where the maximal pressure is reached.

There are three methods for generation of a focused shockwave: electrohydraulic, electromagnetic and piezoelectric. All of these waves are generated in water (inside of the applicator), which allows for a more natural transference of the waves into the body, with limited reflection.

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What is Shockwave continued …

Electrohydraulic shockwaves are high-energy acoustic waves created by the underwater explosion with high-voltage electrode spark discharge. The waves are then focused with a reflector and targeted at the diseased area. It is a true shock wave at all settings.

Electromagnetic shockwaves are created by an electric current passing through a coil to produce a strong magnetic field. A lens is used to focus the waves, and the focal therapeutic point being defined by the length of the focus lens. The amplitude of the focused waves increases when the acoustic wave propagates towards the focal point. It is a true shock wave at high settings only.

Piezoelectric shockwaves involve a large number of piezocrystals mounted in a sphere that receives a rapid electrical discharge that induces a pressure pulse in the surrounding water that leads to a shockwave. The arrangement of the crystals causes self-focusing of the waves towards the target centre, which leads to a precise focusing and high-energy within a defined field. It is a true shock wave at high-energy settings only.

Of these devices, the focal size is largest in the electrohydraulic units and smallest in the piezo-electric units.

RSWT

Radial shock waves are produced by more recently developed pneumatic devices. The term 'radial' refers to the diverging pressure field of the RSWT devices, which reach a maximal pressure at the source of generation (as compared to a focal point away from the applicator). Accelerating a projectile, using compressed air through a tube on the end of which an applicator is placed, generates radial shockwaves. The projectile hits the applicator, which transmits the generated pressure wave into the body. (These waves are NOT generated in water). For all intensive purposes, this operates rather like a pneumatic jack hammer.

Comparing FSWT & RSWT

Some would argue that fundamentally, RSWT should not be called shock wave because of the lack of traditional characteristic physical features of shock wave (e.g. short rise time, a high peak pressure, and non-linearity). The speed of the projectile is not high enough to generate a real shock wave. Thus it has been suggested that RSWT be instead named radial pressure wave therapy. However, since these units are being marketed as 'shock wave', it is of use to include them in this discussion and point out the differences between these units and research into each.

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What is Shockwave continued …

As such, radial shockwave have a more superficial effect compared to focused shockwaves which penetrated and can focus their energies much deeper into the body. On testing RSWT may create a pressure field up to 40mm into water, whereas the pressure field generated during FSWT may reach a distance that is about twice the depth.

Focused shock wave needs to be precisely directed. The waves travel faster than the speed of sound. The energy delivered is described as the energy flux density (the amount or concentration of energy in the focus area). Essentially, the energy is described in three general categories; Low energy (less than 0.27 mJ/mm2), Moderate energy (0.27 – 0.59 mJ/mm2), or High energy (over 0.60mJ/cm2). Both high and low energy can provide an equivalent energy flux density (i.e. 0.3mJ/mm2 and 1000 shocks or 0.1mJ/mm2 and 3000 shocks yield an equivalent EFD of 300 mJ/mm2 each).

Radial shockwaves are programmed to deliver energy reported as ‘bar’ (between 1 – 3 bar typically). The shock waves produced travel at a speed of approximately 10 meters per second (less than those created by focused shock wave.)

Because it is not clear which wave characteristics generate therapeutic effects, it is difficult to relate physical differences between focused shockwaves and radial pressure waves to clinical effectiveness.

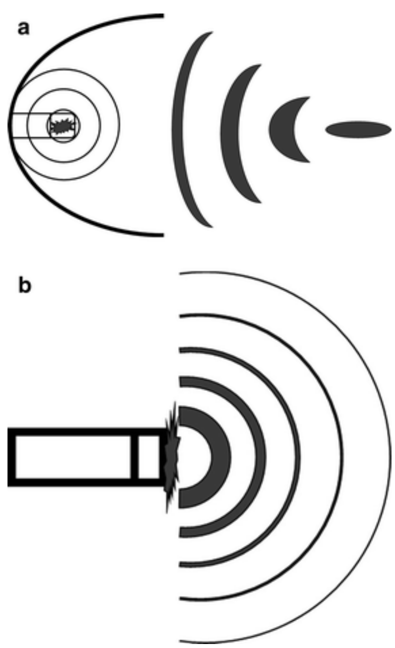

Figure 1

***a** Pressure field of a focused shockwave device (EH-generated by means of spark gap). **b** Pressure field of a radial shockwave device*

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What is Shockwave continued …

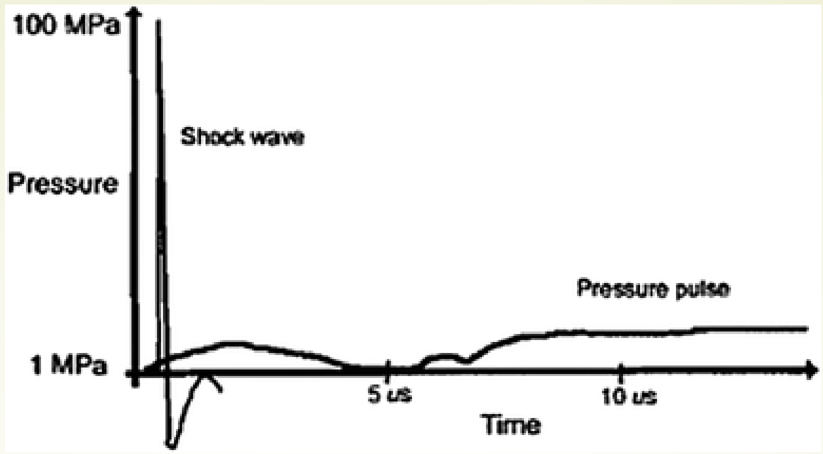

Figure 2

Differences in pressure–time profile of a shockwave (generated with a focused shockwave device) and a pressure wave (generated with a radial shockwave device)

Biologic Response to SWT

More recent studies have investigated the histologic, biochemical and immunologic basic sciences into how SWT affects treated tissues. Enhanced neovascularity, accelerated growth factor release, selective neural inhibition, osteogenenic stem cell recruitment, and inhibition of molecules that have a role in inflammation are some of the mechanisms of action. The most important of which are thought to be the enhanced neovascularity, increased growth factor release and accentuated osteogenic stem cell recruitment. Two major mechanisms seem to be involved in the translation of mechanical shock wave energy into its biological effects. These include membrane hyperpolarization and the formation of oxygen free radicals.

Oxygen free radical production induces a cascade of kinases and growth factors, and the membrane hyperpolarization may enable uptake of these substances.

Indications:

Until more recently, most research into ESWT was conducted using FSWT. However research using RSWT is starting to be revealed, and one can find benefits to both. The fundamental indications for ESWT can be grouped into broad categories such as pain relief, tissue regeneration and destruction of calcification. (These will be discussed in greater detail throughout this newsletter.)

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What is Shockwave continued …

Contraindications

ESWT is not typically used in the presence of bone tumours, certain metabolic bone conditions (where the bone may be too fragile), and certain nerve or circulation disorders (where sensation is impaired or bleeding could be a factor). ESWT isn't typically used in pregnant patients and locations of an open growth plate. It's not currently used in areas where an infection is present, (though there is some early research suggesting ESWT may actually help with infection). It also shouldn't be used in conditions or locations where gas or air is present in the body, (thus caution should be given to locations over the abdomen or chest)--or for other conditions as determined by the healthcare practitioners.

References:

1. Shockwave therapy BC - http://www.shockwavetherapy.ca/about_eswt.htm#What%20is%20ESWT0 Accessed Dec 15, 2014
2. Shockwave therapy - http://www.shockwavetherapy.eu Accessed Dec 15, 2014
3. Cleveland RO et al. Accoustic field of a ballistic shock wave therapy device. Ultrasound Med Biol 2007, 33(8):1327-35.
4. Furia JP et al. Shock wave therapy as a treatment of nonunions, avascular necrosis, and delayed healing of stress fractures. Foot Ankle Clin N Am 2010, 15(4): 651 – 662.
5. Wang CJ. Extracorporeal shockwave therapy in musculoskeletal disorders. J Orthop Surg Res 2012, 7:11.
6. Van der Worp H, et al. ESWT for tendinopathy: technology and clinical implications. Knee Surg Sport Tramatol Arthrosc 2013, 21: 1451-1458
7. Zelle B et al. Extracorporeal shock wave therapy: Current evidence. 2010, 24(3) Suppl 1: S66 – S70.

Shock Wave and Calcifying Shoulder Tendons

Calcific tendonitis of the shoulder is characterized by inflammation around deposits of calcium hydroxyapatite. This condition affects shoulder mobility, can be painful and interferes with day-to-day activities.

After conservative treatment (anti-inflammatory drugs, ice therapy, physiotherapy, corticosteroid injections, and/or needling) has failed, shock wave therapy has been shown to be a good alternative to surgery, however the best treatment intensity remains unknown.

The mechanisms of action of shock wave therapy are unknown. However Loew et al postulate there is a mechanical effect causing fragmentation of the calcification, a molecular effect resulting in phagocytosis, and analgesia caused by denervation of pain receptors.

Pain and Function

Ioppolo et al (2013) conducted a meta-analysis, using the visual analog scale as the outcome measure for assessing pain. Pain reduction was found to be the most immediate finding post shock wave therapy, likely due to washout of inflammatory mediators and nociceptor inhibition. Functional recovery was also seen post shock wave therapy, and both indicators demonstrated clinically significant improvements at 6 months after treatment.

In a study comparing shock wave therapy with ultrasound guided needling, Kim et al found that at 1-year follow-up, the needling group had significantly better scores on the American Shoulder and Elbow Surgeons assessment, the Simple Shoulder Test, and a visual analog scale for pain than those in the shock wave group. The shock wave procedure involved aiming at the sorest spot according to anatomic targeting. FSWT was administered for 3 sessions, 1 week apart (1000 impulses, 0.36 mJ/mm2). Both treatment modalities improved clinical outcomes and eliminated calcium deposits however.

High Energy Focused vs Low Energy Focused for Function

Verstrelen et al (2014) conducted a meta-analysis, using shoulder scores to assess function following *focused shock wave therapy*. At 3-month post intervention marks they found a greater degree of improvement in patients treated with high-energy shock waves (>0.28mJ/mm2) than those treated with low-energy shock waves (<0.08 mJ/mm2). Improvement at the 6-month mark was similar to that at 3 months. All studies concluding that high-energy showed a greater increase in the functional outcomes.

High vs Low for Resorption of the Calcific Deposits Specifically?

Peters et al (2004) compared high-energy (.44mJ/mm2 x 1500 impulses) to low-energy (0.15mJ/mm2 x 1500 impulses) shock wave for dissolving calcifications. Each group participant received 5 treatments, or less if symptoms resolved. At the 6-month follow up no calcification or pain was found in the high-energy group, but all subjects in the low energy group showed residual calcification, and 87% reported pain recurrence.

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Shock Wave and Calcifying Shoulder Tendons continued …

Typically, all studies have shown that *focused shock wave therapy* is effective in the resorption of calcific deposits. However both high and lower energy shock waves can yield improvement as compared a controls receiving no treatment. In the study by Gerdesmeyer et al (2003), high-energy focused shock wave more often results in complete resorption (60% at 6 months, and 86% at 12 months at 0.32mJ/mm2) as compared to low-energy focused shock wave (21% at 6 months, and 25% at 12 months using 0.08mJ/mm2). Dissolution of deposits could be seen as early as 1 week post treatment and remained non-evident at 6 month follow up. (Treatment utilized either 1500 shocks of 0.32 mJ/mm2 or 6000 shocks of 0.08 mJ/mm2 delivered on two occasions, with each group receiving a cumulative energy dose of 0.960J/mm2.)

And Radial? What about Radial Shock Wave Therapy?

Comparing *focused and radial shock wave therapy* in a variety of soft tissue injuries, Speed (2014) found focused, high dose shock wave to be effective in reducing pain and improving shoulder function in cases of chronic calcific tendinopathy. Evidence for the use of radial shock wave therapy was lacking. However, Cacchio et al (2006) performed a study comparing a therapeutic dose of *radial shock wave* once a week for 4 weeks to patients receiving insufficient dosage of shocks. Significant differences in shoulder function and pain were noted in the therapeutic dose group at 6 months. Calcifications disappeared completely in 86.6% of the subjects in the treatment group and partially in 13.4% of subjects; only 8.8% of the subjects in the control group displayed partially reduced calcifications, and none displayed a total disappearance. (The therapeutic RSWT was administered using a 15-mm-head applicator. Each subject in the treatment group received 4 sessions at 1-week intervals, with 2,500 impulses per session (500 impulses with a pressure of 1.5 bar and a frequency of 4.5 Hz and 2,000 impulses with a pressure of 2.5 bar and a frequency of 10 Hz), an EFD of 0.10 mJ/mm2 and a fixed impulse time of 2 milliseconds. The treatment area was prepared with a coupling gel to minimize the loss of shock-wave energy at the interface between applicator tip and skin.)

Adverse Events

Overall, shock wave therapy is a safe treatment option. Reported adverse events and minor side effects include bruising and hematoma which are usually short-lived. Osteonecrosis of humeral head has been reported in a couple of cases.

Conclusion

High-energy shock wave therapy reduces pain and improves function and resorption of calcific deposits better than low-energy therapy in the short and mid term, although improvement is reported at both energy levels.

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Shock Wave and Calcifying Shoulder Tendons continued …

(NOTE: If you have the availability to high-energy shock wave, it seems to be the way to go. However, if you don't have a focused shockwave unit or the ability to sedate an animal, or anaesthetize a region, then I would suggest using more impulses of low-energy focused shock waves to create a higher overall flux energy density (comparable to those delivered in the high-energy studies) or radial shock wave at the dosing discussed in the Cacchio et al paper.)

References:

1. Cacchio A, Paoloni M, Barile A, et al. Effectiveness of radial shock-wave therapy for calcific tendinitis of the shoulder: single-blind, randomized clinical study. Phys Ther 2006;86:672–82.

2. Iopollo F et al. Clinical Improvement and Resorption of Calcifications in Calcific tendinitis of the Shoulder after Shock Wave Therapy at 6 Months' Follow Up: A systematic review and Meta-Analysis. Archives of Physical Medicine and Rehabilitation 2013, 94: 1699-706.

3. Gerdesmeyer L et al. Extracorporeal shock wave therapy for the treatment of chronic calcifying tendonitis of the rotator cuff: a randomized controlled trial. JAMA 2003;290:2573-80.

4. Kim YS et al. Which method is more effective in treatment of calcific tendinitis in the shoulder? Prospective randomized comparison between ultrasound-guided needling and extracorporeal shock wave therapy. J Shoulder Elbow Surg. 2014 Nov;23(11):1640-6.

5. Loew M et al. Shock-wave therapy is effective for chronic calcifying tendinitis of the shoulder. J Bone Joint Surg Br. 1999, 81:863–867.

6. Peters et al. Extracorporeal shock wave therapy in calcific tendinitis of the shoulder. Skeletal Radiol 2004;33:712-8.

7. Speed C. A Systematic review of Shockwave Therapies in Soft Tissue Conditions: Focussing on the Evidence. Br J Sports Med 2014;48:1538-1542.

8. Verstraelen et al. High-energy Versus Low-energy Extracorporeal Shock Wave Therapy for Calcifying Tendinitis of the Shoulder: Which is Superior? A Meta-analysis. Clin Orthop Relat Res 2014, 472:2816–2825

Shockwave and Fracture Healing

It has been reported that about 5 – 10% of the 5.6 million fractures that occur annually in the USA are complicated by delayed union or nonunion. Shock wave therapy (SWT) is a relatively new modality that could be utilized to treat disorders of the bone. SWT seems to produce its effects on bone by upregulating proteins critical for angiogenesis accentuating the release of growth factors important in osteogenesis and stimulating the production of osteoblasts.

Two systematic reviews pertaining to SWT and fracture management were found. Both were conducted in 2010 and both of these studies cite an additional review study conducted in 2002. Studies were conducted on both human and animal subjects. All studies cited in the reviews utilized focused shock wave.

Nonunions

Treatment of nonunions with SWT seems to yield display promising results. The *overall* union rate in patients with delayed union / nonunion was between 73 – 79% (mean was 76%) with the use of shockwave therapy. Hypertrophic nonunions showed a better response to SWT than atrophic nonunions. A couple of studies reported as high as 80% and 100% healing rates specifically for hypertrophic nonunions. The recorded complications from SWT procedures were localized swelling, red spots on the skin from cutaneous vessel bleeding, hematoma and general bruising.

Nonunions are usually treated with 2000 – 6000 shocks using an energy flux density between 0.3mJ/mm2 and 0.6 mJ/mm2. The total number of impulses is usually divided along the proximal and distal margins of the nonunion. The total number of treatments (ranging between 1 – 4) and interval between treatments (ranging from 1 – 4 weeks) vary from paper-to-paper / centre-to-centre. It was noted that the success rate for treatment of non-unions via SWT was as effective as surgery in these cases.

Shockwave and Fracture Healing continued …

Avascular Necrosis

One of the review papers additionally identified 3 human studies whereby SWT was used to treat avascular necrosis (AVN) of the hip. Procedurally, it was noted that a high flux energy density and a relatively high number of shocks were needed due to the depth of the femoral head (as the target tissue). The review remarked that fluoroscopy was critical for accurate targeting, aiming for the junction zone between the viable and avascular bone of the femoral head. Care must be taken to identify and avoid the femoral artery during the procedure. Conclusions drawn from these 3 studies were as follows:

- ROM, hip scores and pain were improved with SWT, and imaging showed substantial reduction in bone marrow edema and no collapse of the subchondral bone.
- SWT was more effective than core decompression and nonvascularized grafting in patients with early stage AVN of the femoral head.
- SWT promotes neovascularity and enhances regeneration and remodeling in avascular necrotic bone.

Stress Fractures

Most stress fractures heal with relative rest and activity modification. Two studies were cited in the review paper that dealt with stress fractures. One study treated chronic stress fractures in athletes using a single high-energy treatment (0.29mJ/mm2 – 0.4mJ/mm2), that enables full healing at 2 – 3.5 months post treatment – allowing all to return to sport. The second study treated athletes with stress fractures with 3 – 4 sessions of low-mid energy SWT (0.09mJ/mm2 – 0.17mJ/mm2 x 4000 shocks per session), resulting in 100% healing at a mean of 8-weeks post treatment.

Additional Findings

Shock wave has been shown to improve bone mineral status, advance bone remodeling (better alignment of collagen fibers and thicker and more mature regenerated fibrocartilage zone) and yield higher tensile load and strength.

References:

1. Birnbaum K et al. Use of extracorporeal shock-wave therapy (ESWT) in the treatment of non-unions. A review of the literature. Arch Orthop Truma Surg 2002, 122(6): 324 – 330.
2. Furia JP et al. Shock wave therapy as a treatment of nonunions, avascular necrosis, and delayed healing of stress fractures. Foot Ankle Clin N Am 2010, 15(4): 651 – 662.

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References continued:

3. Moretti B et al. Shock waves I the treatment of stress fractures. Ultrasound Med Biol 2009, 35(6): 104 – 1049.

4. Wang L et al. Extracorporeal shock wave therapy in treatment of delayed bone-tendon healing. Am J Sport Med 2008, 36(2): 340 – 347.

5. Zelle B et al. Extracorporeal shock wave therapy: Current evidence. 2010, 24(3) Suppl 1: S66 – S70.